

REMARKS

The claims remaining in the present application are Claims 1-3, 6, 8-39, 48-66, 76-88 and 93. Claims 1, 6, 12, 16, 20, 25, 29, 36, 48, 52, 83 have been amended. Claim 93 has been added. Claims 40-47, 67-75, and 89-92 have been cancelled, without prejudice. No new matter has been added as a result of these amendments.

EXAMINER INTERVIEW SUMMARY

On December 30, 2003 representatives for the Applicants conducted a telephonic interview with the Examiner. Claims 12 and 16 were discussed. Horden et al., U.S. Pat. No. 5,812,860 was discussed. Proposed claim amendments were discussed. No definitive agreements were reached.

CLAIM REJECTIONS

35 U.S.C. §102

CLAIMS 12, 16, 20, 25, 29, 36-37, 39-40, 43, 45-46, 48, 52, 56, 60-61, 66-67, 72,
and 76-77

Claims 12, 16, 20, 25, 29, 36-37, 39-40, 43, 45-46, 48, 52, 56, 60-61, 66-67, 72, and 76-77 are rejected under 35 U.S.C. §102 as being anticipated by Horden et al. U.S. Pat. No. 5,812,860. Claims 43, 45-46, 67 and 72 have been cancelled, without prejudice. Therefore, the rejection to Claims 43, 45-46, 67 and 72 is moot. The rejection to Claims 12, 16, 20, 25, 29, 36-37, 39-40, 48, 52, 56, 60-61, 66, and 76-77 is respectfully traversed for the following reasons.

Amended Claim 12 recites:

A method of controlling a computer processor, comprising:
monitoring operating conditions internal to a computer processor;
a computer processor determining a frequency and a voltage at which to
operate said computer processor, based on said internal operating conditions;
and
implementing the determined frequency and voltage.

Claim 12 recites, “a computer processor determining a frequency and a voltage at which to operate said computer processor.” Applicants respectfully assert that Horden fails to teach or suggest the limitations of Claim 12.

Horden fails to teach or suggest a computer processor determining a frequency and a voltage at which to operate a computer processor. Horden may disclose that an operating system determines what frequency and voltage at which to operate a processor. However, this teaching fails to teach or suggest the claimed limitation of a computer processor determining the frequency and voltage, which is vastly different from an operating system performing these tasks.

Moreover, it would not have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify Horden to arrive at the claimed invention. Allowing the processor to determine what frequency and voltage at which to operate a processor provides numerous unexpected benefits over requiring the operating system to make this determination as Horden teaches. For example, having the processor determine the frequency and voltage at which to operate the processor separates processor specific details from general-purpose operating system details. This allows the embodiment of the present invention claimed in Claim 12 to be more compatible with existing operating systems than Horden's teaching. For example, the operating system need only determine idleness in accordance with the embodiment of Claim 12. That is, the operating system may send instructions for the processor to execute, some of which may be halt-type instructions. The processor may analyze the instructions, along with other information, to determine a suitable frequency and voltage at which to operate, based on characteristics known to the processor. Thus, by allowing the processor to determine the frequency and voltage, there is not a need for the

operating system to be modified to achieve the power management benefits. This allows embodiments of the present invention to achieve power management benefits with operating systems that were not designed with such power management capability.

Furthermore, allowing the processor to determine the frequency and voltage provides for a more effective solution over that of Horden's teaching. For example, placing the determination in the processor allows the determination to be tailored to that specific processor or family of processors, thus relieving the operating system of this burden over many different classes of processors. However, placing the determination in the operating system, as does Horden, requires a more generic solution for the wide range of processors on which the operating system may execute. Therefore, it is very difficult for an operating system to provide a solution that is tailored for each processor with which the operating system may be used. This is because characteristics of processors on the market vary dramatically. To accommodate all the processors, the operating system will typically not be tailored for each processor. Rather, the operating system will provide a general solution for all processors. Otherwise, designing and testing the operating system becomes unreasonably difficult.

Further, application specific power information is not required according to the embodiment of Claim 12. This provides a more elegant solution than Horden's teaching, as applications need not be modified to report their processor utilization needs, as some embodiments of Horden require.

For the foregoing reasons, it would not have been obvious to one of ordinary skill in the art, at the time of the Applicants' invention, to realize the Applicants' claimed invention, based on the teachings of Horden.

For the foregoing reasons, Horden fails to teach or suggest a computer processor determining a frequency and a voltage at which to operate a computer processor, as claimed. Therefore, the Applicants respectfully request allowance of Claim 12.

Independent Claim 20 recites, in part:

said computer processor determining a frequency and a voltage at which to operate said computer processor, based on said idle time.

Independent Claim 29 recites, in part:

said computer processor determining a frequency and a voltage at which to operate said computer processor, based on said state.

Independent Claim 48 recites, in part:

a computer processor determining a voltage-frequency pair for said allowable power consumption level.

Independent Claim 76 recites, in part:

a processing unit operable to provide values indicative of operating conditions of the central processor and to cause the power supply and the clock frequency generator to furnish a voltage level and an output clock frequency for the central processor.

For at least the reasons discussed in the response to Claim 12, Claims 20, 29, 48, and 76 are neither taught nor suggested by Horden. Therefore, Applicants respectfully request allowance of Claims 20, 29, 48, and 76.

Claims 25, 36-37, 39-40, 52, 56, 60-61, 66, and 77 depend from Independent Claims 12, 20, 29, 48, and 76. As a result of their dependency from claims that are believed to be allowable, these dependent claims are believed to be allowable.

Amended Independent Claim 16 recites:

A method of controlling a computer processor, comprising:
monitoring operating conditions internal to said computer processor;
determining a frequency and a voltage at which to operate said computer processor, based on said internal operating conditions; and
implementing the determined frequency and voltage, wherein said implementing comprises:
executing instructions in said computer processor while changing voltage at which said computer processor is operated.

Independent Claim 16 has been amended to incorporate limitations from Claim 12, its base claim. Claim 16 has further been amended to recite that instructions are executed while voltage is changed rather than executing instructions while voltage is lowered.

Thus, Independent Claim 16 recites that instructions are executed in the computer processor while changing voltage at which the computer processor is operated. Horden fails to teach or suggest this claimed limitation.

In contrast, Applicants understand Horden to teach operating a processor at a number of discrete voltage/frequency pairs. That is, Horden teaches that instructions may be executed only while at one of the discrete voltage/frequency pairs. Figures 2a of Horden illustrates a graph of power consumption versus frequency for six discrete operating voltages, as indicated by the legend to the right of the graph. Each of the curves indicates the power that would be consumed if the processor were operating at one of the six voltages. However, Applicants note that the graph in Figure 2a does not suggest executing instructions in the processor while changing voltage, as Applicants have claimed. In fact, the graph teaches away from executing instructions in the processor while changing voltage because the graph indicates operating the processor at six discrete voltage levels, each represented by a dot on the graph.

Applicants further assert that while the six curves in Figure 2a are depicted as continuous curves, this does not teach or suggest that instructions are actually executed

in the processor while the frequency at which the processor operates is changed.

Applicants assert that one of ordinary skill in the art, at the time of Horden's filing date, would believe that instructions should not be executed while the processor's frequency is altered due to unexpected behavior of the processor. Since Horden is silent as to any teaching to the contrary, Applicants assert that a reasonable interpretation of the curves of Figure 2a is that these curves represent the power that would be consumed if the processor were operated at a given point on one of the curves, not that instructions are executed while changing the operating point along one of the curves.

Figure 2b of Horden also depicts a graph of power consumption versus frequency. This graph has a first curve with "variable frequency" and "fixed voltage," and a second curve with "variable frequency" and "variable voltage." However, Applicants do not understand either of these curves to teach or suggest executing instructions while changing the voltage at which a processor is operated. Rather, Applicants understand these two curves to teach operating the processor at one of several distinct voltage/frequency pairs. In the "variable frequency" and "fixed voltage" case, only the frequency parameter in the voltage/frequency pair is different between the various pairs. In the "variable frequency" and "variable voltage" case, either the voltage parameter or the frequency parameter may be different between the discrete voltage/frequency pairs. However, it is Applicants understanding that the processor is operated (e.g., instructions executed) at one of the discrete voltage/frequency pairs, not while moving between the voltage/frequency pairs. Applicants note that at col. 5, lines 3-6 Horden teaches that the power savings depends on the granularity, e.g., the number of voltage levels supported. Thus, Horden teaches that while Figure 2b may depict continuous curves with "sample points," Horden does not teach that the processor is actually operated at all points along the curve. Rather, Horden teaches that the processor is only

operated at supported points on the curve that correspond to discrete voltage/frequency pairs that are supported.

For the foregoing reasons, Horden fails to teach or suggest the limitations of Claim 16. Therefore, Applicants respectfully request allowance of Claim 16.

Dependent Claims 25, 36, and 52 recite limitations similar to the discussed limitations of Claim 16. Thus, Dependent Claims 25, 36, and 52 are respectfully believed to be allowable for the reasons that Claim 16 is believed to be allowable.

CLAIMS 89-90

Claims 89-90 are rejected under 35 U.S.C. §102 as being anticipated by Michail et al U.S. Pat. No. 5,832,284 (hereinafter, Michail). The rejection is moot in light of the cancellation of Claims 89-90, without prejudice.

35 U.S.C. §103

Claims 1, 65, 68, 83, and 88

Claims 1, 65, 68, 83, and 88 are rejected under 35 U.S.C. §103 as being unpatentable over Horden. Claim 68 has been cancelled, without prejudice. Therefore, the rejection to Claim 68 is moot. The rejection to Claims 1, 65, 83, and 88 is respectfully traversed for the reasons below.

Claim 1 recites:

A method for controlling power consumption of a computer processor on a chip comprising the steps of:
determining a maximum allowable power consumption level from an operating condition of the processor,
said computer processor determining a maximum frequency which provides power not greater than the allowable power consumption level,
said computer processor determining a minimum voltage which allows operation at the maximum frequency determined, and

dynamically changing the power consumption of the processor by changing frequency and voltage, respectively, to the maximum frequency and the minimum voltage determined.

Claim 1 recites that a computer processor determines a maximum frequency that provides power not greater than the allowable power consumption level. Claim 1 also recites that the computer processor determines a minimum voltage that allows operation at the maximum frequency determined. For the reasons discussed in the response to Claim 12, Claim 1 is neither taught nor suggested by Horden.

Claim 65 depends from Claim 48, which recites, "a computer processor determining a voltage-frequency pair for said allowable power consumption level." For the reasons discussed in the response to Claim 1, Claim 48 is believed to be allowable. Claim 65 is believed to be allowable as a result of its dependency from Claim 48.

Claims 83 and 88 depend from Claim 1, which is believed to be allowable for the above reasons. Therefore, Claims 83 and 88 are believed to be allowable as a result of their dependency from Claim 1.

Claim 83 is believed to be allowable for the following additional reason. Claim 83 recites, "executing instructions in said computer processor while changing voltage at which said computer processor is operated." For the reasons discussed in the response to Claim 16, Claim 83 is neither taught nor suggested by Horden. Therefore, Claim 83 is believed to be allowable for this additional reason.

Claims 2-3, 6, 8-11, 78-79, and 87

Claims 2-3, 6, 8-11, 78-79, and 87 are rejected under 35 U.S.C. §103 as being unpatentable over Horden in view of Weiss et al., U.S. Pat. No. 5,774,703 (hereinafter

Weiss). The rejection is respectfully traversed. Neither Horden nor Weiss, alone or in combination, teach or suggest the limitations of Claims 2-3, 6, 8-11, 78-79, and 87.

Claim 2 recites, in part:

a central processor including:

...

means for detecting the values indicative of operating conditions of the central processor and causing the power supply and clock frequency generator to furnish an output clock frequency and voltage level for the central processor.

Claim 2 recites that a central processor has means for causing the power supply and clock frequency generator to furnish an output clock frequency and voltage level for the central processor. For the reasons discussed in the response to Claim 12 above, Horden fails to teach or suggest these limitations in Claim 2.

Weiss fails to remedy this deficiency in Horden in that the combination of Horden and Weiss fails to teach or suggest these limitations in Claim 2. For example, Weiss teaches a system having a register controllable processor speed (Abstract). However, Weiss does not teach or suggest a processor including means for causing the power supply to furnish a voltage level for the processor, as claimed. While Weiss may teach several sets of registers for adjusting frequency, Applicants do not understand Weiss to teach adjusting the voltage at which a processor operates.

For the foregoing rationale, it is respectfully submitted that Claim 2 is patentable over Horden in view of Weiss. As such, allowance of Claim 2 is respectfully solicited.

Currently Amended Claim 6 recites, in part:

utilizing control software dedicated to a central processor to measure the operating characteristics of the central processor of the computer,

...
the step of determining when the operating characteristics of the central processor are significantly different than required by the operations being conducted comprising utilizing the control software to determine desirable voltages and frequencies for the operation of the central processor based on the measured operating characteristics.

Claim 6 has been amended to clarify that the control software is dedicated to the central processor. Claim 6 recites that control software that is dedicated to a central processor is used to measure operating characteristics of a central processor of the computer. Claim 6 further recites that control software is used to determine desirable voltages and frequencies for the operation of the central processor based on measured operating characteristics. Applicants respectfully assert that the combination of Horden and Weiss fails to teach or suggest using control software for either this claimed measuring or the claimed determining.

As Applicants have previously discussed, Horden may teach using an operating system for determining voltages and frequencies at which to operate. However, Applicants do not understand an operating system to be the claimed control software that is dedicated to a processor. Weiss fails to remedy this deficiency in Horden. Therefore, Claim 6 is believed to be patentable over the combination of Horden in view of Weiss.

For the rationale foregoing reasons, Claim 6 is not obvious over Horden in view of Weiss. As such, allowance of Claim 6 is respectfully requested.

Claim 8 recites, in part:

a central processor including:

...

means for detecting the values indicative of operating conditions of the central processor and causing the power supply and clock frequency generator to furnish an output clock frequency and voltage level for the central processor

Claim 8 recites that a central processor has means for causing the power supply and clock frequency generator to furnish an output clock frequency and voltage level for the central processor. For the reasons discussed in the response to Claim 12 herein, Horden fails to teach or suggest these limitations in Claim 8. Weiss fails to remedy this deficiency in Horden in that the combination of Horden and Weiss fails to teach or suggest these limitations in Claim 8. Therefore, Claim 8 is believed to be patentable over Horden in view of Weiss.

Claim 3 depends from Claim 2. By virtue of its dependency on Claim 2, Claim 3 is believed to be patentable over Horden in view of Weiss.

Claims 9-11 depend from Claim 8. By virtue of their dependency on Claim 8, Claims 9-11 are believed to be patentable over Horden in view of Weiss.

Claims 78 and 79 depend from Claim 76. Claim 76 recites, in part, "a processing unit operable to provide values indicative of operating conditions of the central processor and to cause the power supply and the clock frequency generator to furnish a voltage level and an output clock frequency for the central processor." For the reasons discussed in the response to Claim 12, Horden fails to teach or suggest the limitations in Claim 76. Weiss fails to remedy this deficiency in Horden in that the combination of Horden and Weiss fails to teach or suggest the limitations in Claim 76. Therefore, Claim 76 is believed to be patentable over Horden in view of Weiss. By

virtue of their dependencies on Claim 76, Claims 78 and 79 are believed to be patentable over Horden in view of Weiss.

Claim 87 depends from Claim 1. For the reasons discussed in the response to Claim 1 herein, Horden fails to teach or suggest, "a computer processor determining a minimum voltage that allows operation at the maximum frequency determined," as claimed in Claim 1. Weiss fails to remedy this deficiency in Horden in that the combination of Horden and Weiss fails to teach or suggest the limitations in Claim 1. Therefore, Claim 1 is believed to be patentable over Horden in view of Weiss. By virtue of its dependency on Claim 1, Applicants assert that Claim 87 is patentable over Horden in view of Weiss.

Claims 13-15, 17-19, 21-23, 26-28, 33-35, 38, 42, 44, 49-51, 53-55, 69-71, 73-75, 80-82, and 84-86

Claims 13-15, 17-19, 21-23, 26-28, 33-35, 38, 42, 44, 49-51, 53-55, 69-71, 73-75, 80-82, and 84-86 are rejected under 35 U.S.C. §103 as being unpatentable over Horden in view of Michail et al., U.S. Pat. No. 5,832,284 (hereinafter, Michail). Claims 42, 44, 69-71, and 73-75 have been cancelled, without prejudice. Therefore, the rejection to Claims 42, 44, 69-71, and 73-75 is moot. The rejection to Claims 13-15, 17-19, 21-23, 26-28, 33-35, 38, 49-51, 53-55, 80-82, and 84-86 is respectfully traversed for the following reasons.

Claims 13-15 and 17-19 depend from Claim 12. Claims 21-23 and 26-28 and depend from Claim 20. Claims 33-35 and 38 depend from Claim 29. Claims 49-51 and 53-55 depend from Claim 48. Claims 80-82 and 84-86 depend from Claim 1.

For the reasons discussed above, Horden fails to teach or suggest the limitations in Claim 1, 12, 20, 29, and 48. Michail fails to remedy this deficiency in Horden in that the combination of Horden and Michail fails to teach or suggest the limitations in Claims 1, 12, 20, 29, and 48. Therefore, Claims 1, 12, 20, 29, and 48 are believed to be patentable over Horden in view of Michail. By virtue of their respective dependences, Claims 13-15, 17-19, 21-23, 26-28, 33-35, 38, 42, 44, 49-51, 53-55, 69-71, 73-75, 80-82, and 84-86 are believed to be patentable over Horden in view of Michail.

CLAIM 24

Claim 24 is rejected under 35 U.S.C. §103 as being unpatentable over Horden in view of Klein et al., U.S. Pat. No. 5,913,067 (hereinafter Klein). The rejection is respectfully traversed for the following reasons.

Claim 24 recites:

The method of Claim 20, wherein said monitoring idle time comprises monitoring internal data of said computer processor.

Claim 24 depends from Claim 20. For the reasons discussed above, Horden fails to teach or suggest the limitations in Claim 20. Klein fails to remedy this deficiency in Horden in that the combination of Horden and Klein fails to teach or suggest the limitations in Claims 20. Therefore, Claim 20 is believed to be patentable over Horden in view of Klein. By virtue of its dependency on Claim 20, Claim 24 is believed to be allowable.

Claims 30-32, 57-59, and 62-64

Claims 30-32, 57-59, and 62-64 are rejected under 35 U.S.C. §103 as being unpatentable over Horden in view of Fung et al., U.S. Pat. No. 5,710,929 (hereinafter Fung). The rejection is respectfully traversed for the following reasons.

Claims 30-32 depend from Claim 29. Claims 57-59 and 62-64 depend from Claim 48. For the reasons discussed above, Horden fails to teach or suggest the limitations in Claims 29 and 48. Fung fails to remedy this deficiency in Horden in that the combination of Horden and Klein fails to teach or suggest the limitations in Claims 29 and 48. Therefore, Claims 29 and 48 are believed to be patentable over Horden in view of Fung. By virtue of their respective dependencies on Claims 29 and 48, Claims 30-32, 57-59, and 62-64 are believed to be allowable.

CLAIMS 41 and 47

Claims 41 and 47 are rejected under 35 U.S.C. §103 as being unpatentable over Horden in view of Cepuran et al., U.S. Pat. No. 5,628,001 (hereinafter Cepuran). Claims 41 and 47 have been cancelled, without prejudice. As such, the rejection to these claims is moot.

CLAIM 91

Claim 91 is rejected under 35 U.S.C. §103 as being unpatentable over Michail in view of Cepuran. Claim 91 has been cancelled, without prejudice. As such, the rejection to Claim 91 is moot.

NEW CLAIM

Claim 93 has been added as a dependent Claim based on Claim 12. Claim 93 recites that monitoring of operating conditions internal to the computer processor, which is recited in Claim 12, is performed by the computer processor. Applicants respectfully assert that the prior art fails to teach or suggest a computer processor monitoring operating conditions internal to the computer processor in combination with other elements recited in Claim 93 and base Claim 12.

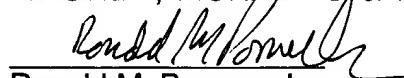
CONCLUSION

In light of the above listed amendments and remarks, reconsideration of the rejected Claims is requested. Based on the arguments and amendments presented above, it is respectfully submitted that Claims 1-3, 6, 8-39, 48-66, 76-88 and 93 overcome the rejections of record and, therefore, allowance of Claims 1-3, 6, 8-39, 48-66, 76-88 and 93 is earnestly solicited.

Should the Examiner have a question regarding the instant response, the Applicants invite the Examiner to contact the Applicants' undersigned representative at the below listed telephone number.

Dated: 2/9, 2004

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